STABILITY OF THE EARLY MARS ATMOSPHERE TO COLLAPSE INTO PERMANENT POLAR CAPS. R.M. Haberle[1], M.A. Kahre[1], R. Wordsworth[2], F. Forget[3], [1]NASA/Ames Research Center, Moffett Field, CA, 94035, USA, Robert.M.Haberle@nasa.gov, [2]School of Engineering and Applied Sciences, Harvard University, Cambridge, MA 02138, USA, [3]LMD, Institut Pierre-Simon Laplace, Universit P. et M. Curie, BP 99, 75005 Paris, France

The presence of a permanent CO_2 polar ice cap on Mars has important consequences for the planet's climate system. The heat balance of such a cap, which is determined mainly by atmospheric heat transport, and the downward solar in infrared radiative fluxes, determines its surface temperature, which through the vapor pressure relation sets the mean annual surface pressure. On Mars today, for example, the south residual CO_2 cap is present year-round with a mean annual temperature of ~ 145 K which corresponds to a mean annual CO_2 vapor pressure of ~ 600 Pa. On early Mars, permanent polar caps are also possible especially since the sun was less luminous 3.5-4.0 Gya. Thus, the existence of permanent polar caps on early Mars is central to understanding the nature of the planets climate system in those ancient times and whether or not the atmosphere might have been capable of sustaining conditions suitable for liquid water flowing over the surface as is indicated in the geological record.

Forget et al [1] showed that for present orbital properties atmospheric collapse into permanent polar caps could only be prevented for surface pressures roughly between 500 – 3000 hPa. Though follow-on studies confirm and extend the Forget et al. results [2], the full sensitivity of this "window" of stability has not been explored. There are many factors to consider such the albedo of the caps, dust content of the atmosphere, and the presence of water ice clouds. However, we begin our exploration of the stability of the early Martian atmosphere by focusing on the role of CO_2 ice clouds. In some preliminary simulations with the Ames Mars General Circulation Model (GCM) we found that atmospheric collapse depends on assumptions regarding the fate of CO_2 ice clouds. If, for example, we assume the clouds immediately fall to the surface, then in some cases collapse is favored. On the other hand if the clouds are allowed to fall and evaporate, collapse can be averted. This implies that CO_2 ice cloud microphysics is important to the overall stability of the atmosphere.

Though the Ames GCM has a sophisticated CO_2 cloud microphysics package that includes nucleation, growth, and sedimentation (see accompanying poster by Kahre et al. [3]), we have implemented a simpler scheme based on the Forget et al. [1] approach to CO_2 ice clouds. Our goal is to reproduce and expand their study. The key parameter in this approach is the concentration and vertical distribution of cloud condensation nuclei (CCN), i.e., dust particles. Fewer CCN lead to larger particles which fall faster, while higher CCN concentrations lead to smaller particles and thicker clouds that remain suspended for longer periods of time. We plan to explore the stability of the atmosphere to CCN concentrations and distributions and then assess the capability of thick early atmospheres to loft and distribute dust particles (CCN) around the planet. Thus, our work will shed light on the nature of the coupling between the dust and CO_2 cycles and the implications it has for the early Mars climate system.

References: [1] Forget et al. (2013) Icarus, 222, 81-99. [2] Soto et al. (2015), Icarus, 250, 533-569, [3] Kahre et al. (2016) Sixth Mars Polar Conference, University of Iceland, Reykjavik, Iceland, Sept 5-9, 2016 (this meeting).